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ABSTRACT

The purpose of this study was to examine whether teachers' personal attributes and school characteristics predict differences in the career patterns of teachers and, if so, to explore the implications for teacher supply. The sample was composed of 786 current and former teachers identified in 1986 through the Teaching Supplement Questionnaire of the fifth follow-up of the National Longitudinal Study of 1972. Statistical methods included descriptive statistics and survival analysis. Data analysis showed that many of the beginning teachers left teaching in the early years of their careers. Science and English teachers were most likely to leave. Teachers who had a master's degree or who had graduated from 5-year teacher education programs tended to stay longer; those with higher beginning salaries tended to stay longer than those with lower salaries; and private school teachers were more likely to leave than public school teachers. Elementary school teachers were more likely to stay than secondary school teachers, and teachers who were more satisfied with teaching s'ayed in teaching longer than those who were less satisfied. Policy implications for teacher supply and teacher education and recommendations for further research are suggested. Three tables and 14 figures are included. (Contains 46 references.) (Author/SLD)

ESTIMATING FUTURE TEACHER SUPPLY: AN APPLICATION OF SURVIVAL ANALYSIS

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Estimating Future Teacher Supply: An Application of Survival Analysis

The purpose of this study was to examine whether teachers' personal attributes and school characteristics predict differences in the career patterns of teachers, and if so, to explore the implications for teacher supply. The sample was composed of 786 current and former teachers in 1986, who were extracted from the Teaching Supplement Questionnaire of the NLS-72 fifth follow-up. Statistical methods included descriptive statistics and survival analysis. Data analysis showed that many of the beginning teachers left teaching in their early years of career; science and English teachers were most likely to leave teaching than those in other subject areas; teachers who had Master's degree or graduated from 5-year teacher education programs tended to stay in teaching longer than those who had other degrees; teacher who received higher beginning salaries tended to stay in teaching than those who received lower salaries; private school teachers were more likely to leave teaching than public teachers; elementary teachers tended to stay in teaching longer than secondary teachers;teachers who were more satisfied with teaching tended to survive in teaching longer than those who were less satisfied. From the findings, policy implications for teacher supply and teacher education, and recommendations for further research were suggested.

How many new teachers will be needed in American schools in the next decade? Will there be enough qualified teachers? The answers to these questions are important to various actors in the educational system. For example, school board members need answers in order to evaluate whether teacher salaries are adequate to attract qualified teachers. Superintendents need information about the characteristics of college students to be teachers, in order to attract qualified teachers their schools. Educational policy makers also need information with which to assess the quality of teacher education programs. The primary mechanism for answering these questions are teacher supply and demand models.

The most frequently cited projections of teacher supply and demand, including numerical projections of the size of the impending teacher shortage or surplus, employ the National Center for Education Statistics' (NCES) national teacher supply and demand model (Murnane, Singer, and Willet, 1988). Unfortunately, the NCES model's projections of teacher shortages and surpluses have proven unreliable in predicting the size and timing of supply and demand imbalances (National Research Council, 1987). The NCES model focuses on a single quantity (that is, the overall attrition rate defined as the percentage of teachers in public schools in the U.S. in one year who are not doing so in the next year) to determine teacher career persistence. Moreover, this model assumes that the attrition of teachers in their careers is the same for teachers with different subject matter specialties. It also assumes that attrition rates do not change over time, and that teachers who leave teaching do not return (Murnane, Singer, and Willet, 1988).

In spite of other contributing factors to teachers' career persistence (i.e., Heyns, 1988) the NCES model used to project teacher supply and demand ignores critical factors known to affect teacher career patterns. In other words, the model lacks an adequate base of descriptive information that pertains to the teacher supply and demand (Grissmer and Kirby, 1987). In order to overcome the shortcomings of the NCES model, this study examines several plausible personal and school-related factors that are believed to contribute to changes in teachers' career patterns over relatively long periods of time (1972-1986).

THEORETICAL BACKGROUND

Career decisions can be categorized according to tendency patterns reflecting career development stages, and the resultant career status or career persistence (represented as leaving or staying) at a given time. While models of career development stages provide useful information for instructional supervision and staff development, information about teachers' career persistence at a specific time is crucial to projecting teacher supply and demand because it includes their mobility patterns in teaching.

Especially, research on organizational behavior reflects continuing interest in employees' job termination behaviors (leaving) such as turnover, exit, absenteeism, withdrawal, intention to leave, and attrition. The general aim of these studies is to deter employee behaviors that are detrimental to organizations and to retain high quality employees. The studies of this type can also be divided into the turnover research focusing on individuals, and aggregate attrition research.

Teacher Attrition in the Macro Context

Attrition studies focusing on groups have examined employee turnover trends in certain jobs or organizations over relatively longer periods than turnover studies focusing on individuals. Many studies and reports have expressed concerns about recent trends and changes in teacher attrition, based on studies exploring macro level conditions that cause defection from teaching.

The International Labor Office (1981) in preparation for the Joint Meeting on Conditions of Work of Teachers reported world and

regional employment trends in teaching. It concluded that shortages of qualified teachers in developing countries result from poor salary and career prospects as well as from working conditions that encourage teachers to leave and young graduates to enter the profession. By contrast, in developed countries the ILO found teacher shortages to be concentrated in specialized subject areas such as language and sciences (i.e., England, USSR, and Ireland), and technical and vocational studies (U.S. and Sweden). The ILO report suggested improving working conditions such as hours of work, class size, pupil-teacher ratios, health and safety as a means of lowering attrition from teaching. It especially suggested material incentives and better working conditions to retain teachers in isolated rural areas.

Similarly, Darling-Hammond (1984) predicted that constantly rising teacher attrition rates and declining academic ability among incoming teachers since 1973 presage an emerging crisis in the Nation's teaching force, leading to serious shortages of qualified teachers, especially in math and science. She attributed decline to factors attracting academically talented women and minorities to occupations that promise greater financial rewards, more opportunities for advancement, and better working conditions. Moreover, she argued that lack of input into professional decision making, overly restrictive bureaucratic control, and inadequate administrative support for teaching contribute to teacher dissatisfaction and attrition, particularly among the most highly qualified members of the teaching force. To counter these trends Darling-Hammond called for major changes in the structure of the

teaching profession including upgrading teacher compensation and creating more professional working conditions.

In an extended study of Darling-Hammond's findings on expected higher teacher attrition rates, Grissmer and Kirby (1987) developed a theory of teacher attrition that attempts to account for disparate reasons for attrition and to explain the patterns of attrition unique to each life cycle and career stage. They argued that voluntary attrition decisions depend on six factors, such as (a) the degree of acquired occupation-specific, location-specific, and organization-specific human capital, (b) the informed nature of the original job commitment and the nature of the original job search, (c) the previous work and teaching experience of the teacher at entry, (d) the probability of changes in marital status, family composition, and residential location after employment, (e) the salary and working conditions of teachers, and (f) the job characteristics and wage levels of alternative opportunities both inside and outside teaching, while involuntary attrition decisions depend on (a) the probability that the performance characteristics of the teacher will meet some threshold level set by the school district, (b) the chance of teacher layoffs, which is primarily influenced by enrollments, fiscal environment, and perhaps union rules, (c) mandatory retirement rules, (d) illness and death.

Noting that the above factors explain teacher attrition, Grissmer and Kirby further argued that the patterns of attrition differ in a career and life cycle context. The major prediction from their theory is that teacher attrition patterns will follow a U-shaped curve over the life cycle. For instance, age-specific

attrition probabilities will be high for younger teachers who are early in their career, very low for middle-aged teachers during the mid-career phase, and high again once teachers become eligible for retirement. They noted that the timing of marriage, birth of children, geographical migration, low salaries, bad teaching assignments, unmet expectations, and family formation could be major causes of higher attrition rates for young men and women teachers during their first 10 years of teaching. However, mid-career attrition (occurring after 10-25 years of teaching experience) is much lower than early-career attrition primarily because of the absence of the earlier occurring factors, and that the accumulation of occupation- and location-specific human capital, and a self-selection process reduce the likelihood of leaving teaching. These arguments were supported by hypotheses testing using national and state level data.

In recent series of annual reports on the condition of teaching in the states, Feistritzer (1985, 1986) and the Carnegie Foundation for the Advancement of Teaching (1990) projected that the nation will need more than half of the current public school teaching force by 1993 due to retirements, leaving for other jobs or simply quitting. This would coexist with rising enrollments and constant teacher-pupil ratios. One of the reports (1986) also predicted that many of the current teachers would no longer be teaching eight years later and that teacher attrition rates will increase dramatically due to an aging teaching force. The reports further argued that academically and physically poor working conditions and low teacher salaries are the primary causes of voluntary teacher

attrition (i.e., leaving for other jobs or simply quitting). Accordingly, the 1986 report recommended increased recruitment of older, experienced teachers to bridge the gap resulting from involuntary attrition (e.g., retirements). Another report (1990) suggested teacher involvement in decision making, the improvement of working conditions, and improving school climate as deterrents of voluntary attrition.

In summary, attrition studies at the macro level provide important insights into future prospects for the teaching force. First, they predict teacher shortages during the next decade, due mainly to voluntary and involuntary attrition. Second, attrition rates have been analyzed at the national level or combined states regional level, using national survey data. Third, some studies draw conclusions about attrition with empirical testing and their results are based on sound frameworks of labor market theory (Murnane, 1984), teacher mobility theory (Murnane, 1981), and career development and human capital theory (Grissmer and Kirby, 1987). Finally, although the studies exhibit several common causes (e.g., salary, working conditions) of teacher attrition on national surveys, they rarely specify a teacher attrition causal model consisting of personal and school predictors in the development of teaching careers. Many of these studies have shown that working conditions or personal factors influencing teachers' affective responses (e.g., commitment, efficacy, satisfaction) are critical for teachers to make decisions of whether they leave or not (Ashton and Webb, 1986; Rosenholtz, 1989; Blossfeld, 1990; Conley, Bacharach, and Bauer, 1989; McClure, Weidman, and Sharp, 1988; NEA,

1988). However, none of the studies at the macro level systematically examined the relationship of these factors to teacher attrition and future workforce projections.

Determinants of Teacher Attrition

Why do teachers leave the teaching profession? Many studies, using data gathered mainly at the state or local level, have identified specific reasons why teachers leave teaching. Micro-level studies on teacher attrition have focused on empirical investigations focusing on a variety of personal and/or school-based determinants of attrition.

Recently, Heyns (1988) analyzed the National Longitudinal Study (NLS) teacher data on the characteristics of the supply pool to identify patterns of entry and attrition over multiple years and to understand the role of school characteristics. After analyzing the effects of such school characteristics as level of instruction, control of school, school location, racial composition, economic status of students, and ability levels of students, she found that rates of attrition were highest in secondary schools, private schools, suburban schools, schools with less than 10% minority enrollment, schools serving students from upper or upper middle class families, and schools with students of high or average ability. Heyns did not report, however, whether career patterns differed by personal characteristics, such as subject specialties, age, gender, and so forth, and when teachers are most likely to leave. Knowing teacher career patterns by subject specialties and when teachers leave these specialties is crucial in estimating

teacher supply in future years.

Using databases drawn from several states, Grissmer and Kirby (1987) studied separate estimates of attrition rates by the teachers' age, teaching levels x age, and subject matters x age. They found that attrition is high among beginning teachers, low for many years among experienced teachers, and then high again for teachers who reach retirement age. whether school levels or subject matters are concerned or not. These findings confirmed their teacher attrition theory in relation to teacher career paths, and concurred with the findings of the Darling-Hammond's study (1984) and Mark and Anderson study (1985). The findings show that because attrition rates are sensitive to teacher characteristics, especially age, teacher career persistence may change as the composition of the teaching force changes. Grissmer and Kirby provided several obvious reasons for voluntary and involuntary attrition. However, they only explained teacher attrition in terms of age, subject specialty, and school (teaching) level. Further, they were unable to make inferences concerning the extent to which attrition rates differed among subsamples and to estimate the proportion of teachers who return to teaching after a career interruption.

On the other hand, several longitudinal studies that have followed samples of teachers who began to teach in a particular school year have reported the percentage of the sample that maintained or left teaching from year to year, in terms of teacher supply and demand. These studies have documented patterns of teacher survival rates and their predictors over long periods using

data collected from several states.

In his earlier work, Charters (1970) identified individual and organizational factors that affect teacher survival in school districts in Oregon. Age, gender, teaching level, and district size appeared as important factors that determine teacher career patterns. In his research, survival rates tend to be higher among male secondary and female elementary school teachers than among their counterparts. More specifically, Charters' findings suggested that survival rates taper off very rapidly after 4 years. Further, Charters found that males tend to survive longer than females, with 79.2% vs. 65.5% survival rates more than one year after entering teaching. Although differential between male and female survival rates decreased over time, it still favored males.

Mark and Anderson (1978) examined data for the period 1968 to 1976 in order to provide a current look at public school teacher survival rates, and to update Charters' findings. Their results indicate that the downward sloping survival curve that Charters found still existed. For example, of the cohort of new entrants to teaching in St. Louis area in 1968, only 64.7% lasted beyond 1 year (male:60.5%, female:66.1%). Further, the survival rate differential between men and women decreased over time to a point where the rates were virtually identical. In their follow-up study on teacher survival rates in St. Louis, 1969-1982, Mark and Anderson (1985) found that high attrition rates continue to exist in the beginning years of teaching for each entering cohort. Further, survival rates appeared to have peaked for cohorts entering in the early 1970s, with survival rates declining substantially for subsequent cohorts.

Then, beginning with the cohort entering in 1975, females began to have higher survival rates than males, a reversal from the pre-1975 cohorts.

In his earlier study, Murnane (1981) examined the mobility patterns of teachers in one large urban school district for the period from 1965 to 1974, using logit analysis. He found that teacher seniority and changes in student enrollment are much more important in exploring transfers and terminations in the 1970s than in the 1960s. While gender had no any effect on job attrition over the period, teachers' years of experience in teaching and racial compositions in their schools were factors that have significant, but minor impacts on attrition. This suggests that teachers in their early years of teaching and in White teacher-dominated schools tend to leave teaching more frequently than teachers in other settings. Finally, Murnane argued that patterns of mobility no longer reflect primarily teacher preferences. Instead, they increasingly reflect the pattern of declining enrollments and operation of rules that govern the disposition of surplus teachers. These findings differ substantially from prior studies focusing on the effects of teacher preferences on teacher attrition.

Extending Murnane's research, Eberts (1982) analyzed the effects of specific teacher contract provisions on New York teacher attrition from 1972-1976 and in the process assessed the validity of two theories, human capital and labor market theories, explaining teacher mobility, using logit analysis. He reported that class size increases the probability of transfers and reduces the probability of quits, but that seniority affects quit (attrition)

rates only in districts with rapidly declining enrolment. On the other hand, gender and racial composition did not substantially impact teacher attrition across districts with increasing, slightly declining, and rapidly declining enrollments. He concluded that teacher mobility reflected the voluntary decisions of teachers attempting to improve the quality of their jobs during the teacher shortage of the 1960s, but that work rules (e.g., contract provisions) was more useful in explaining teacher attrition/transfer during the teacher surplus of the 1970s.

During the 1980s, Murnane and his associates initiated studies on teacher attrition, its predictors, and its application for teacher supply based on data from several states using survival analysis techniques. They have found a variety of personal and school-based predictors that influence teachers' survival rates. In a study, Murnane, Singer, and Willet (1988) examined teachers' career paths by age, gender, and subject specialties. They reported that (1) young women have the shortest teaching career (low survival rate), (2) many teachers return after a short career interruption, (3) chemistry/physics teachers tend to shorter careers in teaching than teachers of other subjects and are unlikely to return to teaching, and (4) salaries in teaching could stimulate teachers to seek other job opportunities, although this was not empirically tested.

To recapitulate, teacher attrition studies at the micro level have found a list of personal predictors (i.e., subject specialty, gender, race, salary, type of certification, college GPA, education, age, and career satisfaction) and school-based

predictors (i.e., location, sector, teaching level, racial composition, economic status of students, size, and average academic ability of students).

Problem Statement

A variety of factors identify several stages of teaching careers that are critical to teacher career development and the effectiveness of policies aimed at balancing teacher supply and demand. However, few studies have focused on the nature of these stage related changes. Teacher supply and demand policies have often been made without the aid of appropriate descriptive information about changes in teacher career patterns over long periods of time. Widespread criticisms of a simple projection model on teacher supply and demand suggest that the model should be based on empirically identified predictors of teacher career patterns that change over time.

Accordingly, this study examines whether there are significant differences in teachers' career patterns and examines when teachers change their careers, in terms of their personal and school predictors. This study uses information on differences in career patterns and changes in these patterns over time, to answer the following research questions:

1. Are there differences in teachers' career persistence by personal characteristics (subject specialty, gender, race, salary, type of certification, college GPA, and level of education)?

2. Are there differences in teachers' career persistence by school characteristics (location, school sector, teaching level,

racial composition, economic status of students, size, and average academic ability of students)?

Using methods associated with survival analysis, the answers to the questions provide information not only as to whether specific events in teachers' careers may serve as predictors at particular points in time, but also when the transitions are likely to occur. Then, the answers to the questions will be used to predict future teacher supply.

METHODOLOGY

Data and Sample

This study was mainly based on the Teaching Supplement Questionnaire (TSQ) that follows the fifth follow-up survey of the NLS-72. The TSQ was sent to all respondents to the fifth follow-up survey (1986) who indicated on Question 118 that they were (1) a current teacher, (2) a former teacher, and (3) trained as a teacher but had never taught. Of 14,489 respondents (actually, 12,841 completed), 1,517 individuals responded to Question 118 with a (1), (2), or (3).

Of those 1,517 respondents, 1,449 were mailed Teaching Supplement Questionnaires. The total member of questionnaires returned was 1,147 (86% response rate). Of these, 1,038 questionnaires were returned complete, and the other 109 questionnaires were discarded because the respondents were not teachers and had no degree in education or certification to teach. The 1,038 respondents were distributed as (1) 455 current teachers who maintained teaching as of 1986 (stayers), (2) 331 former

teachers who left teaching (leavers), and (3) 252 non-teachers who were trained as teachers but never taught. Therefore, the final sample for this study consists of 786 current and former teachers who were drawn from the nation's elementary and secondary schools.

This sample of current and former teachers were asked about career paths, salaries in teaching, certification, continuing education, demographic information, reasons for entering into teaching and attrition, school information, and years of entering or leaving teaching. This information provided a unique opportunity to study career dynamics of teaching. It provided an opportunity to examine the development of teaching careers from very early stages and to follow the students who eventually became teachers. It also allowed us to compare those teachers who were still teaching in 1986 to those who had left teaching.

Research Variable

The independent variables for this study are grouped into 1) personal predictors representing individual attributes of teachers and 2) school predictors representing organizational characteristics of their schools. Personal predictors include teachers' subject specialty, gender, race, salary, type of certification, college GPA, career satisfaction, and education.

The independent variables for this study are concerned with teacher survival and attrition. Items representing the variables were drawn from the NLS-72 data sets, such as the Fifth Follow-up, the Postsecondary Education Transcript Study (PETS), and the TSQ. Except for college GPA, all the independent variables are based on

responses to questions by teachers. The independent variables were used individually as categorical variables that differentiate teacher survival by criterion group.

Subject taught is defined as a subject area taught most frequently in the last two years (or the last two years the respondent taught); sciences (1), math (2), vocational education (3), social science (4), humanities (5), physical education (6), special education (7), and other education (8).

Gender indicates that female teachers are coded as "1" and male teachers "0".

Race indicates that white teachers are coded "0" and all other minority teachers "1".

Salary is defined as a teacher's beginning salary as used in most studies that examined relationships between earnings and teachers' career decisions (Murnane, 1981; Eberts, 1982; Murnane and Olsen, 1989). Salary is categorized as a value of "1" for low-salary teachers (lower than $ 8,500), "2" for medium-salary teachers ($ 8,501 - $ 9,999), and "3" for high-salary teachers (more than $ 10,000).

Type of certification indicates type of state teaching certification a teacher holds. Those holding provisional certificates, who lack some requirements, are coded "0" and regular certificators "1" .

College GPA is taken from the PETS and is defined as a standardized grade of college GPA reported by schools current and former teachers attended. The college GPA considered here is obtained from their Bachelor's degree program. The GPA is coded as

"1" for low academic performers (lower than 2.88), "2" for medium performers (2.89 - 3.26), and "3" for academically able performers (more than 3.27).

Education is defined by the highest degree an individual teacher obtains. It is assigned a value of "1" for teachers who had associate degrees, a value of "2" for teachers who completed college education (Bachelor's degree) as of 1986, a value of "3" for teachers who obtained a Master's degree, a value of "4" for teachers who obtained a specialist or 6-year certificates, and a value of "5" for teachers who obtained a Doctorate degree.

School predictors include location, sector, teaching level, racial composition, economic status of students, size, and average academic ability of students.

Location describes the place of a teacher's current (most recent) school. It is coded as "1" for rural schools, "2" for suburban schools, and "3" for urban schools.

Sector is defined as type of school control. It is coded as "0" for public schools and "1" for parochial and private schools.

Teaching level indicates the school level at which a teacher taught. It is coded as "1" for secondary schools including junior high and middle schools and as "0" for elementary schools.

Racial composition is defined as the proportion of minority students in a teacher's current (most recent) school. It is assigned a value of "3" for schools with all white students (less than 10% minority), "2" for those with integrated students (10 - 60%), and "1" for those with minority students (over 60%).

Economic status of students is coded as "1" for schools with

upper or upper middle class students, "2" for schools with lower and lower middle class students, and "3" for schools with mixed class students.

Size is defined as the student enrollment at a teacher's current or most recent school.It is categorized as small enrollment (less than 386) coded "1", medium enrollment (387-685) coded "2", and large enrollment (more than 686) coded "3".

Academic ability of students describes an academic ability level of students in a teacher's current or most recent classes. It is given "1" for schools composed of students with high or average ability level, "2" for schools with low ability, and "3" for schools with widely differing ability.

The dependent variable is teachers' career duration in teaching or teaching spell based on their career persistence at a given time (1986). The variable was obtained from the TSQ. Career duration is defined as the length of teaching spell or waiting-time for which a teacher stay in teaching from entry to teaching to exit during the data collection period. Information about teachers' career duration time was obtained from both stayers and leavers during the period of 1972 - 1986.

While leavers' teaching spells remain as fixed information within the period, stayers' spells are flexible due to their continuity in teaching. That is, teachers who may not have left teaching by the end of the data-collection (or for whom the event of interest does not happen) cannot help possessing truncated or "right-censored" waiting-times or duration.

The direct analysis about all teachers' waiting-times during the

data collection period (1972 - 1986), including teachers' with right-censored waiting-times, underestimates the true length of teachers' remaining in teaching in 1986. Therefore, this study deals with right-censoring by employing the survival analysis teaching or event history analysis that make mathematical transformations of waiting-time that remain meaningful in the face of right-censoring and then transform back during the interpretation of the analyses. Thus, in order to protect underestimation of parameters waiting time or caused by right-censored information career duration time to an event (staying or leaving) transformed into the survivor function (or survival probabilities) or hazard function (or hazard probabilities) as a new dependent variable that will be detailed.

Analytic Procedures

The primary technique for this study is called event history analysis or survival analysis (Allison, 1982, 1984; Willet and Singer, 1988). The technique focuses on the length of time to a response. The response is an event that occurs at a specific point in time and refers in this study to leaving or remaining in the teaching profession. The time-to-response is also called waiting-time or survival time to an event at a given time. Thus, event history analysis deals with "a longitudinal record of when events happen to a sample of individuals" (Allison, 1984).

As briefly mentioned earlier, however, the obvious problem in analyzing event history data is that the event of interest may not have occurred during the data collection period. During the period

for this study (1972-1986), nearly half of the sampled teachers maintained their teaching spells. Therefore, the length of the teaching spell for them cannot be determined because they were still teaching or, methodologically speaking, they were "right-censored". If information about right-censored teachers is excluded from or included in (without any treatment) event history data analysis, the true length of first spell would be underestimated. Therefore, censored information should be accommodated in specific statistical models using event history analysis (Allison, 1984; Tuma, 1982; Tuma and Hannan; 1984) or survival analysis (Kalbfleisch and Prentice, 1980; Miller, 1981).

Due to right-censored cases, the time-to-response or length of time (or duration) in first (or initial) teaching as an original dependent variable is mathematically transformed into the survivor function (or survival probability) and the hazard function (or hazard probability). The mathematical transformation makes right censored information during the interpretation of the data analyses (1972 - 1986). Therefore, the survival probability and the hazard probability function as new dependent variables throughout all the event history analyses to follow.

The survivor function[1] is a plot which indicates the

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[1] The survivor function (or survival probability) at time is the probability that a teacher does not leave teaching prior to time t or that he/she survives beyond t. The survivor function $S(t)$ is given as

$$S(t)=P(T\geq t)=exp[-\int^{t}h(u)du] \text{ in continuous time}$$
$$\text{or}$$
$$=Prob[\text{survival beyond } t] \text{ in discrete time,}$$

where T is a continuous random variable for duration of the

probability that a selected individual will remain a teacher beyond a particular time, more simply speaking, how likely it is that a teacher will survive in teaching beyond 1 year, 2 years, 3 years, and so on. Thus, survival probabilities can be estimated for each year after entry and are interpreted as the percentage of teachers (survived to a year or at risk) who are continuing on to the next year without having left. They provide a picture of survival as a function of time. At the very beginning of the study, when all the teachers have just started their teaching, none of them left in the first year, hence their survival probability is 1.00, interpreted as 100% of the teachers surviving beyond year 1. As time passes, teachers gradually start to leave teaching, and the survival probability drops steadily, although it may not reach zero during the period of observation due to right-censoring (Murnane, Singer, and Willet, 1988).

In this study the survivor function is assumed to be a continuous function on each interval year (i.e., 0.0-1.2, 1.2-2.4, 2.4-3.6 years, and so on), so a linear interpolation on a midpoint between the data points is used (Cox and Oakes, 1984). That is because the points of cumulative proportion surviving (or estimates of the survivor function) only at beginning of interval years are given. Interpretation of cumulative proportion surviving is the same with the survival probability in discrete time.

In addition to a picture showing changes in survival probabilities plotted on each interval year, the survivor function provides a useful summary statistic estimated from the

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risk period for an event.

probabilities, "estimated median survival time". It summarizes the time point at which half the teachers in the sample have left teaching, and which is useful in understanding how rapidly the survivor function drops and how long a teacher might expect to stay in teaching.

The hazard function[2] (or hazard probability, hazard rate, instantaneous rate of failure) is defined as the (conditional) probability of risk or rate that a teacher will leave teaching after a particular point of time in teaching, given that the teacher has taught continuously until that time (Allison, 1984). In discrete time, for instance, when comparing the teacher who entered in 1978 and left in 1983, with another teacher who entered in 1981 and was censored in 1986, the hazard probabilities for the first teacher are "0" for the first four years and "1" for the fifth year. But, the probabilities for the later teacher are "0" for all five years because s/he never left, although the two teachers taught for the same five years. Thus, teachers' probabilities of risk of leaving teaching can be collectively estimated for each

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[2] The hazard function (or hazard rate) is the instantaneous risk of leaving teaching at time t, given that the event did not occur before time t. The hazard rate $h(t)$ in continuous time is given as

$$h(t) = \lim_{\Delta t \to o} \frac{P(t+\Delta t > T \geq t \mid T \geq t)}{\Delta t} = \frac{f(t)}{S(t)}$$

or

$$= \lim_{\Delta t \to o} \frac{\{Prob[leaving\ between\ t\ and\ t+\Delta t \mid Survival\ to\ t]\}}{\Delta t}$$

In discrete time,
$h(t) = Prob\ [leaving\ between\ t\ and\ t+1 \mid survival\ to\ t]$.

year in teaching.

The greater the hazard function, the greater the risk of leaving teaching. By knowing hazard probabilities in each of the years, we can tell whether the second year of teaching is particularly risky compared with the other years, when a particular year is most risky, and how risk trends vary depending on time or other factors.

For the purposes of interpretation, the survivor function and the hazard function can be taken together. That is, hazard also functions as a measure of how rapidly the slope of the survivor plot is changing. For instance, if the survivor plot drops quickly from one particular time to the other, we can explain that many teachers have left teaching at that period or, inversely, that period is very hazardous or risky for teaching. Thus, hazard functions can be described in association with changes in the survivor functions.

Survivor functions and hazard functions can be modeled in terms of two groups of predictors in this study. Both survivor and hazard functions are compared among teachers' personal attributes (e.g., male vs. female, white vs. minority, inter-subjects). They also are compared by subgroups of school characteristics (e.g., elementary vs. secondary, public vs. private, rural vs. suburban vs. urban). In addition to pictorial comparisons of the functions among the predictors, the listings of the 75th and 50th (median survival) percentiles of the survivor function are presented as summary statistics for comparison. For each group of the predictors, then, the summary table is presented with the total number of teachers, the number leaving teaching and censored (staying), and proportion

censored. Lastly, the Mantel-Cox test is done to see whether the survivor functions obtained for the groups of the predictors are equal (Benedetti, Yuen, and Young, 1990)[3].

R E S U L T S

Descriptive analysis

This study initially included 455 current teachers and 331 former teachers in 1986. Of all 786 subjects sampled, 9 subjects were excluded for this study, since they did not answer most of the item questions items including those on duration of teaching. Thus the final sample included 777 subjects. Several continuous variables consisted of that number of subjects, in case missing values were substituted with mean values: salary, GPA, size, racial composition, entry age, years of teaching experience, and career satisfaction. Some discrete variables maintained complete 777 cases (gender, subject, marital status, and teaching level), while the others did not. Table 1 shows descriptive statistics of research variables: mean, standard deviation, minimum value, maximum value, and number of cases.

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[3] It is exponential scores test which was scores based on the expected value of order statistics from an exponential distribution. It is known as the log-rank test that gives equal weight to all observations.

The Mantel-Cox test is one of four nonparametric linear rank tests provided in in the 1L of BMDP. The others include the Tarone-Ware, Breslow, and Peto-Prentice tests. When interpreting the results of the statistical tests, consideration should be given to the sample size, and the pattern and amount of censoring, since the distribution of the test statistics and reported *p*-values are based on asymptotic statistical theory. When only a small sample of subjects is used, the test results should be interpreted with care.

In this sample, teachers' per capita beginning salary was $9,250, which was a bit below the United States average of $9,494 in 1980. In terms of college GPA, subjects appeared to have high average of GPA, 3.05. It is the same in its median value with 2.88 GPA of one third percentile and 3.26 of two thirds percentile. Most of the subjects entered teaching at the age of 24.4, held 5 years of their first teaching spell, and obtained Bachelor's as a highest degree (64.3%). In terms of racial composition of students in their schools, most subjects taught at schools with 0% to 40% minorities of the total student population (71.4%).

Duration by Personal Attributes

Research Question 1 is composed of several specific questions to see how the patterns of first teaching duration differ depending on teachers' personal attributes: gender, race, college GPA, subject, salary, certification, and education.

Duration by gender. Figure 1 displays survivor functions by gender. Compared to male teachers' duration pattern in teaching, female teachers appeared to have nearly the same pattern.

Table 2 exhibits the survival statistics that summarize survival patterns by gender and test their differences. There are no unique gender differences in teaching spell. The estimated survival time for 75 percent of female teachers was 2.41 year, while the time for male teachers was 1.49. This result was very slightly reversed for the estimated median survival times, but there is no actual difference in the times between male and female teachers. Several test statistics consistently evidence no difference in first

teaching duration between them. Therefore, there can be no generalizations made about the effect of gender on survival probabilities based on years in teaching. This finding was also found for a national sample (NCES, 1991) and for several state samples (Kemple, 1989; Title, 1990).

Duration by race. Figure 2 dispalys obvious differences in cumulative proportion surviving by race. It indicates that minority teachers persist longer in their overall in teaching that white teachers, as was also found by Kemple (1989).

The differences in first teaching duration were summarized and tested in Table 2. Minority teachers have more censoring proportion (0.61) and have longer estimated median survival time (9.77) than white teachers have 0.48 for censoring proportion and 6.06 year for the survival time. In terms of the median survival time at which half of the teachers have left teaching, minority teachers stayed in first teaching three and half year longer than did white teachers. Test statistics consistently show the significant difference in survivor functions between minority and White teachers at the .05 level. Therefore, minority teachers tend to stay in teaching longer than white teachers. This result reversed findings from NCES (1991), Chapman and Hutcheson (1982), and Murnane and Olsen (1987) that reported a slight or no differences between white and minority teachers.

Duration by GPA. Figure 3 shows that teachers with medium GPA tend to occupy the top of the cumulative proportion surviving plots until year 10, followed by teachers who have high GPA. In terms of the proportion of censored cases which means the percentage

teachers survived to the end of the data collection period, teachers with medium GPA represent the highest proportion of censored cases (54%).

According to Table 2, teachers who have medium GPA have the longest estimated median survival time (8.87 year). It is about three year longer in the survival time than 5.92 year for academically able teachers. This suggests that academically proficient teachers make a quick exit from teaching and stay less in first teaching than do others. Test statistics reaffirm the substantial difference in survival probabilities between teachers with the three levels of academic ability at .05 level. Therefore, both academically proficient and poor teachers tend to leave teaching more frequently than teachers with mediocre ability.

Duration by subject. Figure 4 clearly shows that special education teachers and other education teachers (mainly, elementary teachers) remain in their first teaching duration longest of all the subject matters. To the contrary, teachers who teach sciences, humanities (mainly, English), and vocational education tend to stay less than teachers who teach the other subjects.

In Table 2 special education teachers had the longest estimated median survival time (9.81), followed by social studies teachers (7.96 year) and then elementary teachers (7.86 year). Although social and elementary teachers were expected to have the longer survival times, special education teachers were not thought to. Special education areas have been thought to be one of the subjects that have high attrition rates (NCES, 1991). That is, however, not the case for this sample. Meanwhile, science teachers appeared to

have the shortest median survival time (4.08 year), then followed by vocational education teachers were found to have relatively a high risk of leaving teaching, as elsewhere (Ibid.). The teachers would be lured out of the profession more easily than elementary and social studies teachers, because the former teachers have better abilities and skills that are more attractive to alternative employers than do elementary and social studies teachers. Besides inability to find work outside, another possible explanation may be that elementary teachers tend to be more satisfied to remain in the classroom (Title, 1990).

On the other hand, test statistics based on survival information by subjects show statistically significant differences in duration time among subjects at the 0.01 level. Science, vocational, and English teachers tend to leave teaching more often than teachers with other subjects. Previous findings on duration by subjects were confirmed in this study, except for special education teachers.

Duration by salary. Figure 5 shows that teachers with medium and high salaries tend to stay longer in teaching than teachers with low salaries. According to Table 2, while teachers with medium and high salaries have more than seven year median survival time, teachers with low salary only have 5.4 year survival time. This result can be also sensed from distribution of censored cases. More than half the teachers with medium and high salaries survived to 1986, whenever they entered teaching, whereas only about 40% of low paid teachers survived to that year. Duration differentials between teachers with three levels of salary were statistically significant at the .05 level. Teachers with higher than average salaries tend

to stay in teaching longer than those with lower salary.

These findings espouse that career duration is positively related to salaries (e.g., Becker, 1975; Murnane and Olsen, 1988; Zabalza, Turnbull, and Williams, 1979). That is, the more a teacher earns, the more likely s/he is to stay in teaching. In their recent studies using state data, however, Kemple (1989) and Title (1990) failed to empirically evidence "salary effects on first teaching duration". They attributed this to (1) Black teachers' tendency to stay in teaching due to unequal opportunities in changing occupations; (2) a lack of salary variation among teachers in their samples; (3) the benefits of working conditions in the profession that may outweigh the salary consideration. But they generally agree that high salaries keep teachers from leaving teaching for other occupations.

Duration by certification. As expected, regular certificants appeared to stay longer than the counterparts in Figure 6. The survival probability differences between both certificants made clear on years in teaching duration. The results looked clearer from survival statistics in Table 2. The difference in estimated median survival times was nearly seven years, while the difference in proportions censored was about sixty percent more for regular certificants. Test statistics verified the differences with statistical and substantial significance at an absolute level (.0000). Provisional certificate holders are more likely to leave teaching regular certificate holders.

A likely explanation for the short careers of provisional certificants may be that these teachers were granted temporary

teaching certificates in order to fill emergency vacancies (Kemple, 1989). These teachers would then have been replaced when a new group of regular certificants entered teaching in the following year.Therefore, the teachers with provisional certificates probably did not return because they did not upgrade their certificates to a regular status.

Duration by level of education. Figure 2 shows that teachers with Masters and Specialist degrees tend to stay longer than teachers with lower or higher degrees. Teachers with Doctorate and Associate degrees were positioned far below in their cumulative proportion surviving plots. Teachers with Bachelor degree moved their plots down between teachers with Master/Specialist and Associate/Doctorate degrees. Most noteworthy, teachers with Associate and Doctorate degrees were dramatically less likely than others to persist throughout the first seven years of teaching.

Table 2 summarizes the patterns of survival plot depending on levels of education. As expected, teachers with Master's degrees (10.60 year) and Specialist degrees (8.35 years) had longer median survival times than did teachers with Bachelor's (5.24 year), Doctorate (2.98 year), and Associate degrees (2.96 year). The former stayed in teaching 3 to 8 years longer than the latter, in terms of estimated median survival times. This result was also found in proportions of censored cases, in which more than 50% of the teachers with Master and Specialist degrees maintained their teaching until 1986. Test statistics showed that differences in summary statistics between teachers with the levels of education are statistically significant at an absolute level (.000). Master

and Specialist degree teachers tend to stay in teaching substantially longer than others. These results differ from those of recent NCES short-term survey (1991) showing that Specialist degree teachers had the highest annual attrition rate, then followed by Bachelor's, Master's, Doctorate, and Associate degree.

Duration by School Characteristics

Reseach question 2 consists of several specific questions used to determine whether durations in teaching vary depending on teachers' school characteristics: teaching level, school sector, academic ability, economic status of students, school size, racial composition of school, and school location.

Duration by teaching level. Figure 8 displays the plot of survival patterns by teaching level. Elementary school teachers were found to have longer years in teaching than secondary school teachers. These patterns were reflected in survival statistics by teaching level in Table 3. Elementary teachers appeared to have nearly three year longer median survival time than secondary teachers. The proportion of teachers surviving to 1986 was 55 percent for elementary teachers and 44 percent for secondary teachers. The differences between both sets of teachers were significant at the .01 level. Therefore, elementary teachers tend to stay substantially longer in teaching than secondary teachers.

Why do elementary teachers persist longer in teaching? Two possible explanations have been made for the question. Generally, secondary teachers, especially science or English teachers, have skills that provide them with better chances to find alternative

employment outside teaching, and therefore they tend to leave teaching more frequently (Title, 1990). Elementary teachers, on the other hand, who do not need special skills in teaching tend to stay in teaching. The other likely explanation is that elementary teachers are typically move satisfied with their careers than are secondary teachers (Heyns, 1988). Elementary teachers tend to be satisfied with the rewards they obtain from teaching, and therefore persist longer in teaching.

Duration by sector. Figure 9 shows a conspicuous difference between public and private schools, in terms of the cumulative proportion surviving pattern. As expected from past studies, public school teachers tend to stay longer than private school teachers. The differences between teachers in the two schools were very straightforward in terms of survival statistics by sector. As seen in Table 3, half of public school teachers remained in teaching 4.5 year longer than did half of private teachers. Comparing survival times at the 75th percentile for both groups, we can state that many private teachers tend to leave teaching within the first few years. Test statistics showed the differences in teacher survival patterns between public and private schools at an absolute level. Thus, public teachers are more likely to remain in teaching than private teachers.

This finding seems ironical, because we know private schools excel public schools in student outcomes and teacher outcomes. However, we must remember that many private teachers who leave earlier tend to enter teaching in public schools. Previous research has attributed early private teacher attrition to unfavorable

working conditions and unmet monetary compensation in private schools (Heyns, 1988).

Duration by academic ability. As replicated, Figure 10 shows that teachers at schools composed of students of widely differing ability levels tend to stay longer in teaching than those at schools with the other two levels. However, school teachers at the three levels of ability drew the same patterns of survival probability plots.

As presented in Table 3, teachers at schools with differing levels of student ability were censored by 57 percent, which means that more than half of them remained in teaching until 1986. This result also indicates that these teachers had the longest median survival times (9.7 years), longer by 3 to 4 years than those of teachers at schools with higher and lower academic levels. Test statistics showed the differences in summary statistics between teachers at the three levels of academic ability to be significant at the .05 level. It concluded that teachers who work at schools composed of differing levels of student academic ability tend to stay in teaching longer than other teachers.

The average academic level of students in a school is one of the working conditions that affect teachers' satisfaction and commitment. Therefore, the high level of student ability was anticipated to influence teachers' duration in teaching. From the results, however, a higher level of student ability is not associated with longer teacher duration in teaching. Rather, teachers remained longer at schools with various levels of student academic ability.

Duration by economic status. Figure 11 presents cumulative survival patterns by three levels of economic status. Teachers who worked at schools composed of mixed class families were found to stay longer in teaching than those at schools with lower and upper class families. Although teachers from mixed class schools were plotted in their survival probabilities above those from upper and lower class schools, most survival plots between upper and lower schools overlapped.

As shown in the survival plot, Table 3 showed that teachers who were at schools with mixed class families had the longest median survival time (10.4 year). It nearly double the times for teachers at upper class and lower class schools. When the results from the summary statistics were tested, however, the differences in survival times among teachers in the three classes were not statistically significant. Duration differences were substantial between teachers at mixed class schools and at upper or lower class schools, though.

The results run counter to a common belief that teachers working at schools with economically advantaged families and resources are more satisfied with their teaching careers, so they are not likely to leave. The economic status of students in a school proved to be a non-additive, non-linear function in predicting teachers' duration in teaching. That is to say, the variable was not a good predictor of teachers' decisions about whether to stay or to leave.

Duration by school size. Figure 12 displays cumulative proportion surviving patterns by school size. Although the pattern differences are not quite plausible, teachers in medium- and large-

sized schools tend to stay longer in teaching than those in small-sized schools. The survival probability gaps between both groups of teachers appear obvious during years 2 through 6.

As exhibited in Table 3, teachers in medium-sized schools (5.3 years) and large-sized schools (7.3 years) have longer median survival times than those in small-sized schools(5.3 years). These patterns in median times were also found by Title (1990). That is, the larger the school size, the longer the median survival time. Median survival times by size in this study were quite similar to those from the North Carolina sample in Title's study. Test statistics verified the duration differences by size at the .05 level, except for the Mantel-Cox test. Therefore, teachers in larger-sized schools tend to stay longer in teaching than those in small-sized schools.

Why do teachers in larger schools or districts remain longer in teaching? From human capital theory, teachers seeking to maximize their returns on accumulated skills and knowledge may find opportunities, such as those for advancement and promotion, greater in large-sized schools or districts (Ibid.), which have more positions in the school hierarchy. Therefore, teachers in small-sized schools or districts may transfer into large ones. Further, teachers are more likely to leave small schools because these schools usually offer worse working conditions. Teachers in small schools are usually assigned heavy teaching and work loads. Beginning teachers may also be forced to teach at small-sized schools with unfavorable working conditions. Therefore, teachers in small-sized schools or districts tend to move to larger schools or

districts after a few years of teaching in small ones.

Duration by racial composition. Figure 13 presents cumulative proportion surviving patterns by racial composition. The patterns are not discernable by sight: there are similar survival patterns of plots for years in teaching, although teachers in white-dominant schools are positioned at the bottom of the patterns.

The fuzziness in differentiating survival patterns of the three groups of teachers is reflected in the survival statistics shown in Table 3. In terms of estimated survival time, teachers who work in schools with integrated and large minority populations appear to have slightly longer times than those in schools with large white population. There were, however, no statistically significant differences between them. Therefore, there were no substantial differences in survival times between teachers who worked in schools with three types of minority populations.

This result is not consistent with Title's findings. Title found, in his samples from three states, that teachers from districts with large minority populations are more likely to leave teaching rapidly, and vice versa. It is taken for granted that white teachers prefer to teach in schools that do not have large minority populations (Title, 1990). A similar assumption would be made for minority teachers. From this study, however, we may tentatively conclude that teachers may seek to teach in schools which contain an ethnic mix of students.

Duration by location. Figure 14 indicates that teachers tend to have similar patterns of survival plots over all first teaching years. Urban teachers had the same survival probabilities until the

sixth year, then they became positioned above those of rural and suburban teachers.

In terms of summary statistics in Table 3, urban teachers had a longer median survival time (8.7 years) than did rural teachers (7.5 years), and suburban teachers (6.0 years). The differences between the three groups of teachers, however, were found to be statistically insignificant. Thus, there were no substantial differences in first teaching duration among teachers from urban, suburban, and rural schools.

The results of this study were consistent with the findings of an NCES survey (1991). What is important to note is that urban teachers are usually at risk of leaving the profession in their early years of teaching, then they appear to survive longer if they overcome their early risks. Survival trends of suburban teachers are also noteworthy. Although suburban teachers are generally believed to enjoy better working environments, their duration in teaching is not much longer than that of urban teachers.

C O N C L U S I O N S

This study was conducted to contribute to understanding teachers' career patterns by identifying and validating characteristics of teachers and their schools that have been found to predict such patterns. More detailed knowledge about teacher career patterns was expected to produce important implications for teacher supply projections. Based on the findings of the study,the following conclusions were drawn.

First, beginning teachers were more likely to leave teaching.

They were at the highest risk of leaving the profession during the first two years. This phenomenon was common to every beginning teacher, whatever his or her personal and school characteristics.

Second, the subjects teacher taught influences how long teachers remain in their initial teaching stage. Career patterns in teaching varied depending on which subject they taught. Science (e,g., chemistry, physics, biology) and English teachers tended to leave teaching earlier and more than teachers with other subjects. While many studies have examined aggregated effects of math and science teachers on teacher career patterns, the effects of both subjects appeared to be separable. Science teachers tended to leave the profession more often than math teachers. Human capital theory explains that science and English teachers were more likely to leave teaching, because they have skills and abilities more applicable to business and industrial occupations that provide better material benefits.

Third, teachers who had Master's degrees or graduated from 5-year teacher education programs tended to stay in teaching longer than those who had the other degrees. The Master's degree was one of the most powerful predictors that influence teachers' survival in teaching. Teachers with Master's degrees were less apt to leave teaching than were those with Bachelor's degrees. Otherwise, teachers who had associate and doctoral degrees tended toward very short careers in teaching.

Fourth, regular certificate holders tended to stay in the first teaching stage longer than provisional certificate holders. The risk of leaving teaching for regular certificate holders was

approximately half the risk of provisional certificate holders.

Fifth, teachers who received better beginning salaries tended to have longer teaching durations than those who received lower salaries. Lower-paid teachers were at higher risk of leaving the profession during the first six years.

Sixth, private school teachers were more likely to leave teaching than public school teachers. Private teachers' survival in teaching was more than twice that of their counterparts. As reported in other studies (Heyns,1988), many of the private teachers who left teaching earlier tended to enter teaching in public schools because of unfavorable working conditions and low pay in private schools.

Finally, elementary school teachers tended to stay in teaching longer than secondary teachers. Secondary teachers were at more risk of leaving teaching across all years in teaching than were elementary teachers. Human capital theory argues that elementary teachers who do not need specific skills in their teaching areas tend to stay in teaching due to few job opportunities outside teaching. The other possible explanation is that elementary teachers are typically more satisfied with teaching than secondary teachers (Heyns,1988).

I M P L I C A T I O N S

The findings ans conclusions of the study can provide several imlications for policy practice. First, the findings can be utilized for the models that states and the federal government use to predict teacher supply and demand. As indicated in other studies

When the projection models consider information on teacher career patterns, the personal effects model seems to be more informative than the school effects model. The former appeared to be better able to identify which kinds of teachers tend to leave or remain in teaching earlier or more than other models. In addition to school sector and teaching level considered in current teacher supply models, the following personal attributes of teachers should be considered to be important factors in projecting future teacher supply: race, subject specialty, beginning salary, type of certificates, and levels of education.

Attrition rates for states that consider some factors are different from national attrition rates, vary from state to state, and even differ over time (National Research Council, 1990). The variety of local information should be used to support national projections of teacher supply and demand.

Second, structural alternatives to extend current teacher education programs, such as 5-year programs or Master programs, are encouraged by the findings of this study. Many types of structural alternatives for improving the quality of teacher education programs and teaching candidates appeared during the educational reform era of the 1980s. While the alternatives have not been appropriately evidenced in terms of their effects on prospective teachers or current teachers, or because they were sometimes doomed to fail (Feiman-Nemser, 1990), the findings of this study endorse reliance on the 5-year and Master-level teacher education programs in terms of their substantial effects on lengthening the duration of teaching.

(Murnane, Singer, and Willet, 1988, 1989; Grissmer and Kirby, 1987), projections from these models have utilized a single attrition rate at which the current stock of teachers is leaving the profession. Further, most models assume that (1) the single attrition rate is the same for teachers in all subject areas, (2) attrition rates do not change over time, and (3) teachers who leave teaching do not return. Those assumptions, however, have proven untrue in other studies (e.g., Beaudin, 1988; Title, 1990).

Instead of considering new college graduates the only source of teacher supply, future teacher supply should be projected on the basis of reversed information against the above assumptions of current teacher supply models. English and science teachers tended to leave teaching more often than teachers of other subjects. As the result, the nation's schools will need more teachers who teach those subject areas in future. It is necessary that future teacher supply be projected depending on subject areas. Moreover, attrition rates change over time and former teachers tended to return to the classroom after a short break. Therefore, more realistic, accurate projections of the balance between teacher supply and demand (1) should be based on teacher career patterns using a variety of predictors examined in this study, particularly subject areas, (2) should identify the size and composition of the reserve pool of potential teachers (e.g., former teachers, and certificate holders who never taught) certified to teach, (3) should understand the factors that influence former teachers' decisions to leave and to return to teaching, and (4) should consider long-term changes in attrition rates obtained from local and national data.

Third, teacher certification systems need to be reviewed in terms of retaining high quality teachers. Regular certificate holders tended to stay in teaching longer than provisional certificants. Generally, the provisional certificates were awarded on a one-year basis to teachers who had not met one or more requirements for a regular certificate. Teachers with provisional certificates could upgrade their certification by meeting the missing requirement or they could renew the provisional certificate by demonstrating their intent to fulfill the missing requirement (Kemple, 1989). However, most of the teachers with a provisional certificate tend to have a short spell in teaching because they would be replaced by teachers with a regular certificate. Accordingly, states or districts with many provisional certificants in their teaching force need to consider mobility patterns when projecting teacher supply and demand. Further, the patterns may influence school administration and personnel management in dealing with these very unstable teaching force.

Fourth, teacher salary should be considered for increasing teacher retention. Several recent reports have indicated the wide discrepancy between teachers' salaries and those of other professions (Carnegie Task Force on Teaching as Profession, 1986; Holmes Group, 1986). They lament the fact that lower teacher salaries have constantly discouraged many undergraduate students, particularly the most academically talented, from considering teaching as career. Although little is known about exactly how salaries influence teachers who have already entered teaching, recent studies have found that teachers who are paid higher

salaries tend to remain in teaching longer than those who are paid lower salaries (Murnane and Olsen, 1989, 1990; Murnane, Singer, and Willet, 1989). This issue is important to local school districts. The best and brightest of teaching force are being lured to business and industry where salaries are higher, particularly in the fields of sciences, math, and English (College Placement Council, 1988). Policy makers at the local level need to know if raising teacher salaries is an effective way of lengthening the time the current teaching force is likely to stay in teaching. In this context, the findings of this study suggest that policy makers design competitive salary schedules to compete with business or industrial jobs current or prospective teachers may choose. Particularly, policy measures on salary schedules should be seriously taken into consideration for teachers in shortage, such as science teachers.

The findings and conclusions of the study also suggest several implications for further research. Future research on teacher supply and demand needs to be more comprehensive in modeling teacher supply and demand projections. In addition to relying on the simple demographic data, teacher supply and demand studies have to consider more comprehensive, detailed information concerning teacher career patterns and flexible policy variables. As one of teacher supply components, information on teacher career patterns needs to be utilized more (1) for constructing refined models of teacher supply and demand, (2) for more accurately predicting how many teachers in a specific area will be needed in years to come, and (3) for making concerted efforts to attract and retain more

qualified teachers in teaching. In short, future research needs to be shed more lights on teacher career patterns.

Educational researchers, who intend to study teacher career patterns or the other topics related to duration or persistence, should be encouraged to try a variety of event history analysis techniques. Proportional hazard modeling, which was recently developed and introduced in educational research, has been found to be appropriate and powerful in fully understanding (1) teacher career patterns (e.g., Murnane, Singer, and Willet, 1988; Kemple, 1989), (2) the patterns of graduate students in their doctoral programs (e.g., Civian, 1990), and (3) the longitudinal patterns of student dropouts (e.g., Willet and Singer, 1991). Although event history analysis remain somewhat difficult to understand due mostly to the logic and principles of its mathematical functions and transformations, it is becoming accessible because computerized event history analysis programs are widely available through statistical packages such as SPSS, SAS, and BMDP.

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Table 1. DESCRIPTIVE STATISTICS OF RESEARCH VARIABLES

Variable	Mean	S.D.	Min.	Max.	N
Personal Attributes					
Gender			0	1	777
Race			0	1	773
Salary	9519.96	3510.04	1	3	777
GPA	3.05	.47	1	3	777
Certificate			0	1	774
Education	2.40	.66	1	5	722
Subject			1	8	777
School Characteristics					
Sector			0	1	755
Teaching level			0	1	777
Location			1	3	739
Size	686.93	706.54	1	3	777
Racial composition	3.99	1.36	1	6	777
Economic status			1	3	741
Academic ability			1	3	758

TABLE 2. SURVIVAL STATISTICS BY PERSONAL ATTRIBUTES

Variable		Summary Statistics						Mantel-Cox test
		Total	Leaving	Censored	Prop. Censored	75th	Median	
Gender	Male	210	103	107	0.51	1.49	6.83	0.13
	Female	566	287	279	0.49	2.41	6.67	
	Totals	776	390	386				
Race	White	678	350	328	0.48	2.07	6.06	4.59***
	Minority	94	37	57	0.61	3.70	9.77	
	Totals	772	387	385				
GPA	Low	258	135	123	0.48	1.70	5.44	5.84*
	Medium	256	118	138	0.54	2.95	8.87	
	High	262	137	125	0.48	2.21	5.92	
	Totals	776	390	386				
Subject	Science	48	28	20	0.42	1.18	4.08	22.17**
	Math	57	33	24	0.42	2.13	5.53	
	Vocational	40	24	16	0.40	1.19	4.53	
	Social sci.	52	24	28	0.54	1.17	7.96	
	Humanities	179	105	74	0.41	1.38	4.73	
	Physical ed.	52	21	31	0.60	2.37	6.15	
	Special ed.	97	38	59	0.61	5.03	9.81	
	Others	250	117	133	0.53	5.31	7.68	
	Totals	775	390	385				
Salary	Low	267	155	112	0.42	1.76	5.40	6.67*
	Medium	220	111	109	0.50	2.08	7.39	
	High	289	124	165	0.57	2.86	7.98	
	Totals	776	390	386				
Certi-ficate	Provisional	174	119	55	0.32	0.78	2.20	87.44***
	Regular	598	268	330	0.55	3.54	9.29	
	Totals	772	387	385				
Education	Associate	11	8	3	0.27	1.60	2.96	42.00***
	Bachelor	463	262	201	0.43	1.56	5.24	
	Master	200	74	126	0.63	4.82	10.60	
	Specialist	39	16	23	0.59	5.05	8.35	
	Doctorate	7	5	2	0.29	0.98	2.98	
	Totals	720	365	355				

Note : a) * $p<.05$ ** $p<.01$ *** $p<.001$

TABLE 3. SURVIVAL STATISTICS BY SCHOOL CHARACTERISTICS

Variable		Summary Statistics						Mantel-Cox test
		Total	Leaving	Censored	Prop. Censored	75th	Median	
Teaching level	Elementary	420	190	230	0.55	2.80	8.34	8.27**
	Secondary	355	200	155	0.44	1.73	5.66	
	Totals	775	390	385				
School sector	Public	619	285	334	0.54	2.58	8.26	32.72***
	Private	134	92	42	0.31	1.00	3.83	
	Totals	753	377	376				
Academic ability	Higher	329	182	147	0.45	1.94	5.53	8.84*
	Lower	166	84	82	0.49	1.87	6.46	
	Differing	261	112	149	0.57	2.82	9.72	
	Totals	756	378	378				
Economic status	Upper	183	95	88	0.48	2.64	5.99	5.67
	Lower	415	221	194	0.47	1.88	5.86	
	Mixed	141	59	82	0.58	2.37	10.36	
	Totals	739	375	364				
School size	Small	259	142	117	0.45	1.58	5.31	5.52[b]
	Medium	220	102	118	0.54	2.72	8.10	
	Large	297	146	151	0.51	2.55	7.30	
	Totals	776	390	386				
Racial composition	Minority	122	55	67	0.55	2.13	7.36	0.90
	Integrated	318	163	155	0.49	2.78	7.22	
	White	335	172	163	0.49	1.62	6.15	
	Totals	775	390	385				
School location	Rural	206	100	106	0.51	2.19	7.53	0.68
	Suburban	412	218	194	0.47	2.22	5.96	
	Urban	119	55	64	0.54	1.71	8.71	
	Totals	737	373	364				

Note : a) * $p<.05$ ** $p<.01$ *** $p<.001$
b) Except for the Mantel-Cox test, the other tests(Tarone-Ware, Breslow, and Peto-Prentice) showed significant differences between the sizes at the .05 level.

FIGURE 1. CUMULATIVE PROPORTION SURVIVING BY GENDER

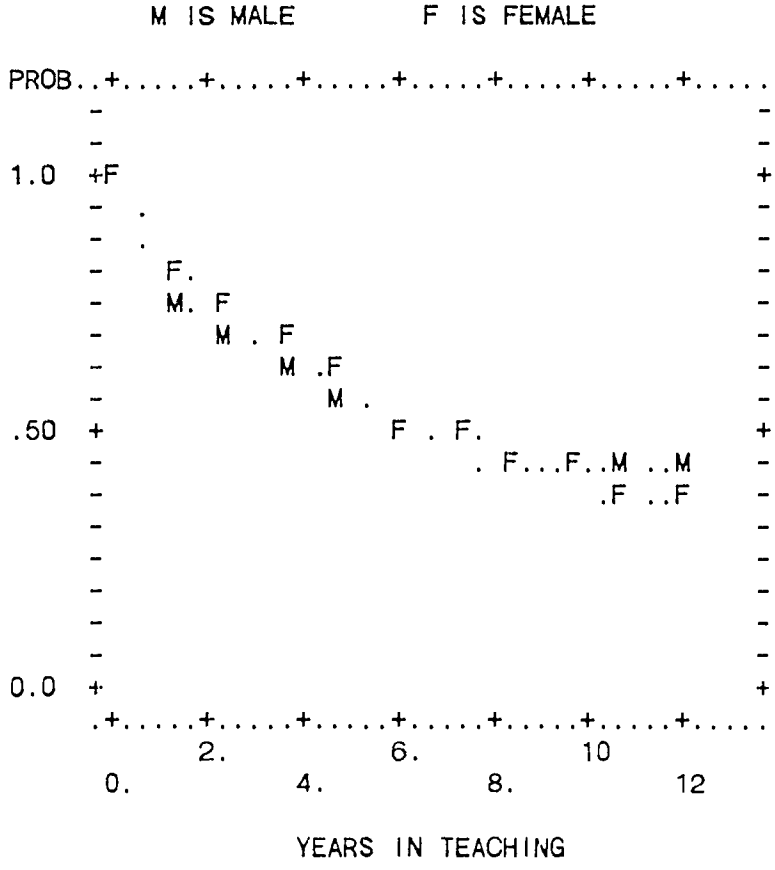

FIGURE 2. CUMULATIVE PROPORTION SURVIVING BY RACE

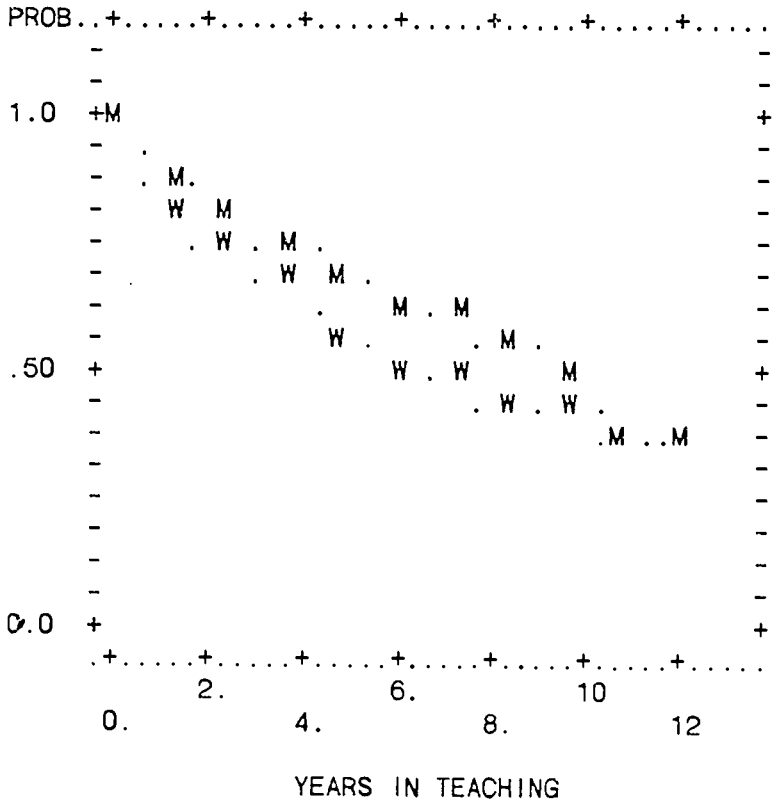

FIGURE 3. CUMULATIVE PROPORTION SURVIVING BY GPA

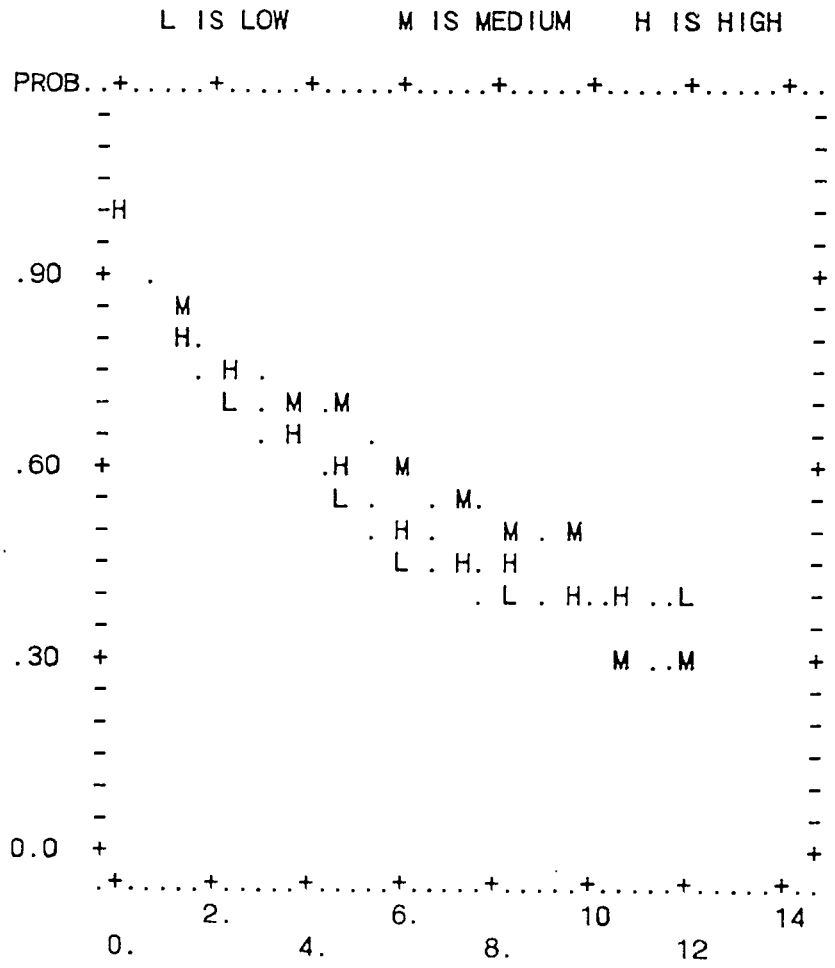

FIGURE 4. CUMULATIVE PROPORTION SURVIVING BY SUBJECT

S IS SCIENCE M IS MATH V IS VOCATIONAL ED. X IS SOCIAL
H IS HUMANITIES P IS PHYSICAL ED. Z IS SPECIAL ED. O IS OTHER

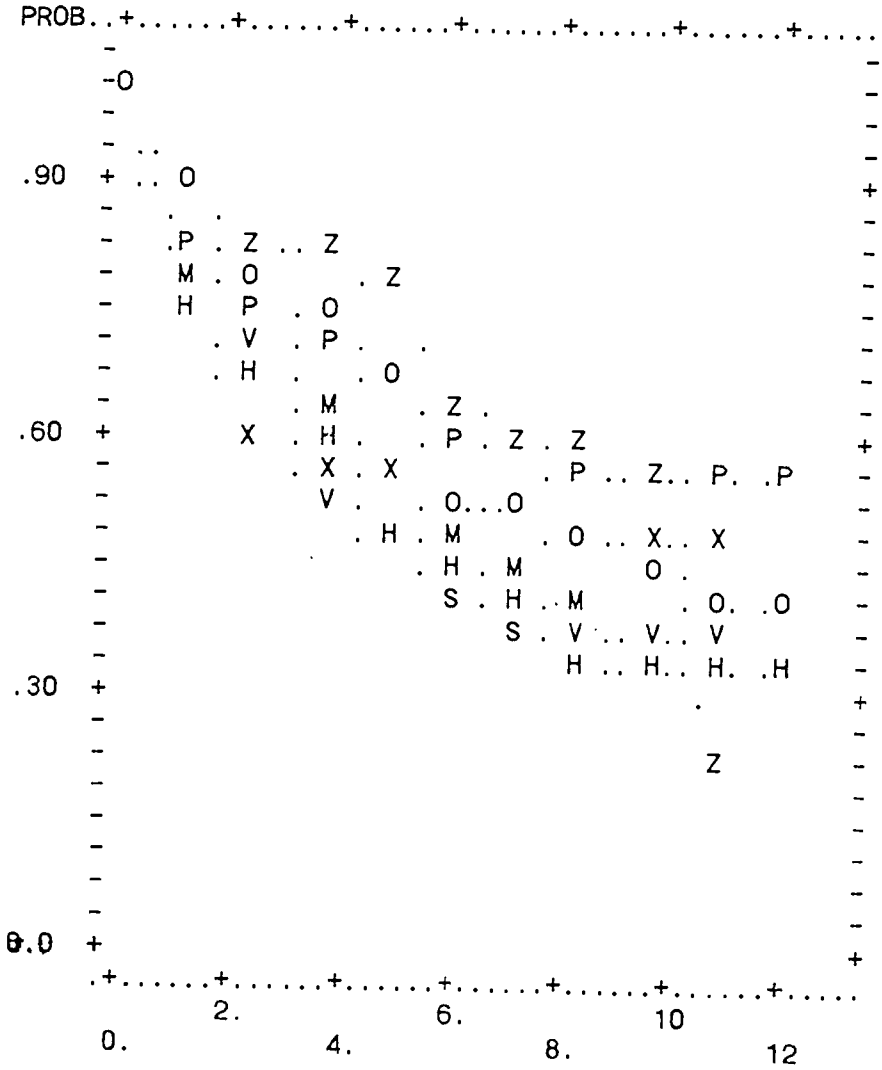

FIGURE 5. CUMULATIVE PROPORTION SURVIVING BY SALARY

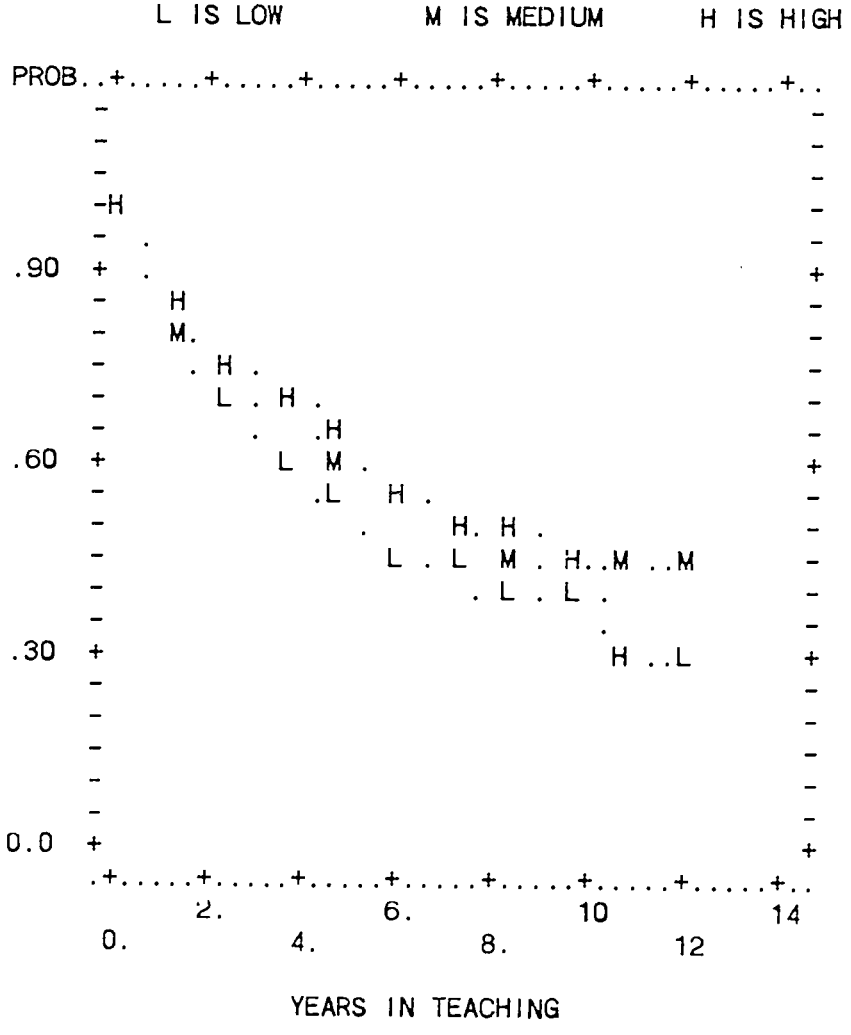

FIGURE 6. CUMULATIVE PROPORTION SURVIVING BY CERTIFICATION

P IS PROVISIONAL R IS REGULAR

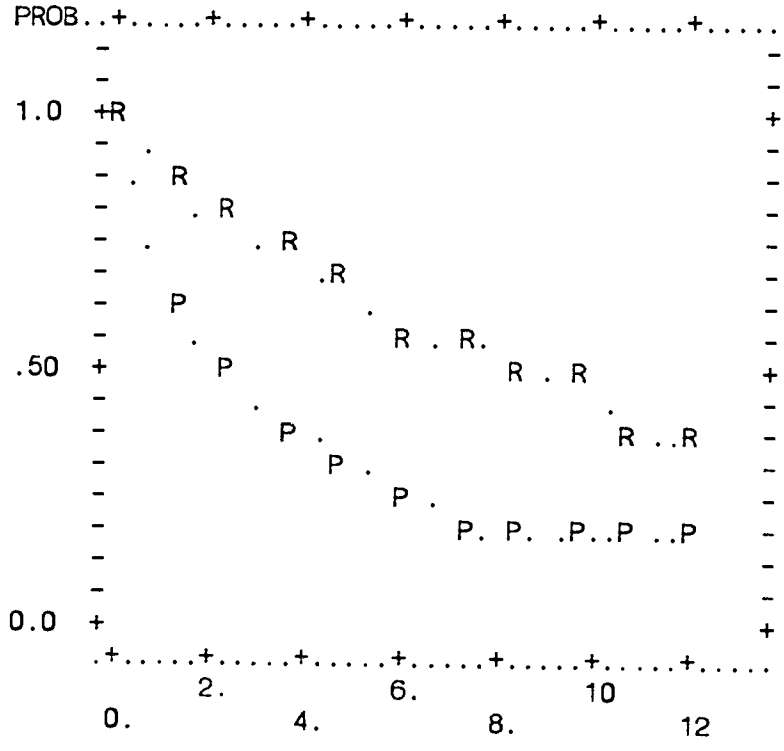

FIGURE 7 . CUMULATIVE PROPORTION SURVIVING BY EDUCATION

A IS ASSOCIATE B IS BACHELOR M IS MASTER S IS SPECIAL
D IS DOCTORATE

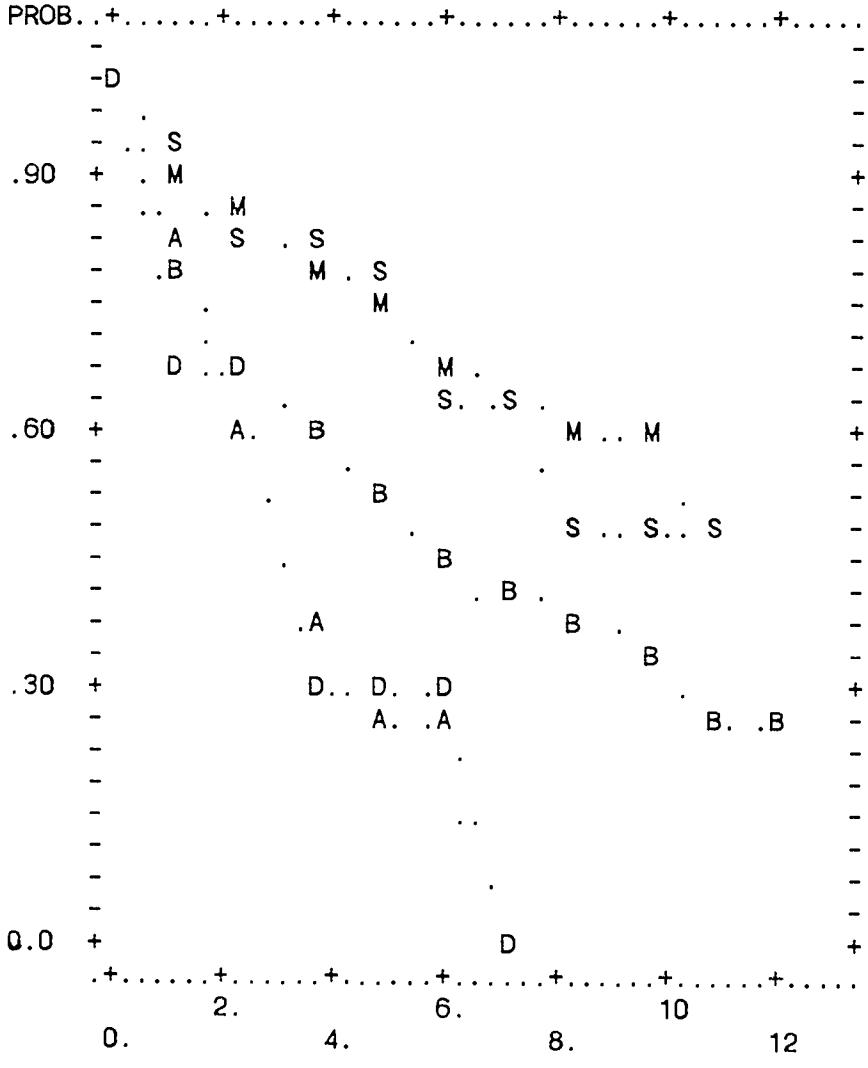

FIGURE 8. CUMULATIVE PROPORTION SURVIVING BY TEACHING LEVEL

E IS ELEMENTARY S IS SECONDARY

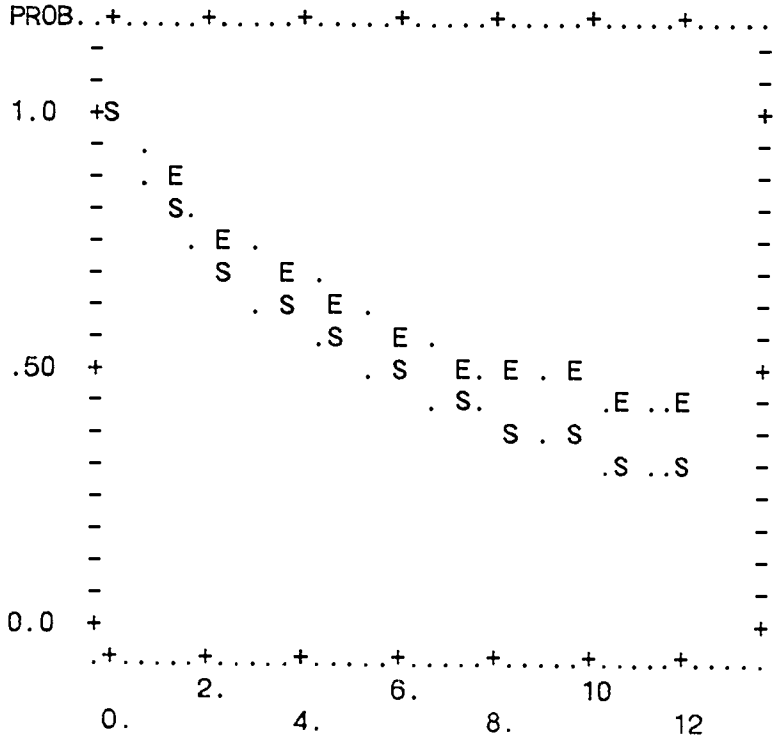

FIGURE 9. CUMULATIVE PROPORTION SURVIVING BY SECTOR

P IS PUBLIC N IS PRIVATE

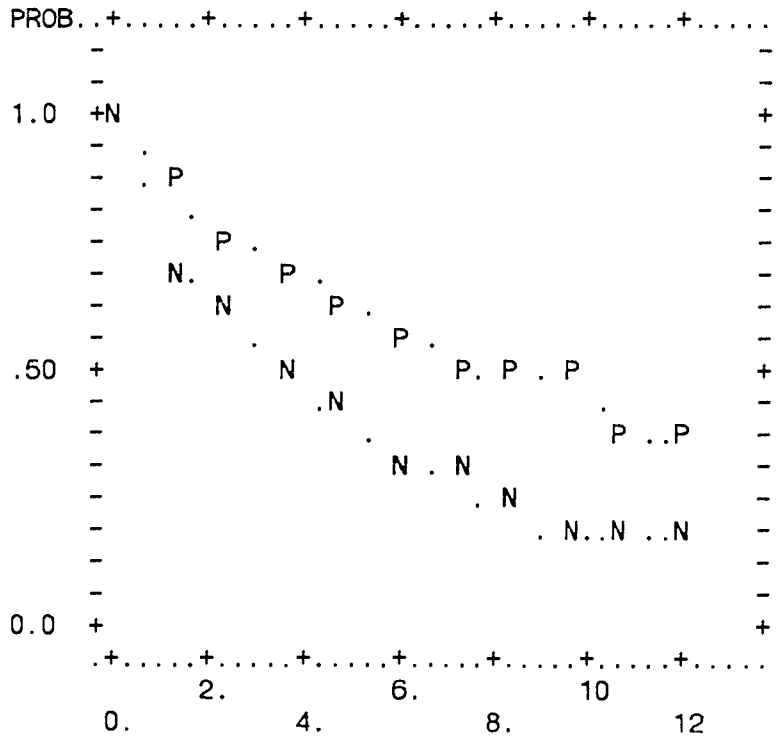

FIGURE 10. CUMULATIVE PROPORTION SURVIVING BY ABILITY

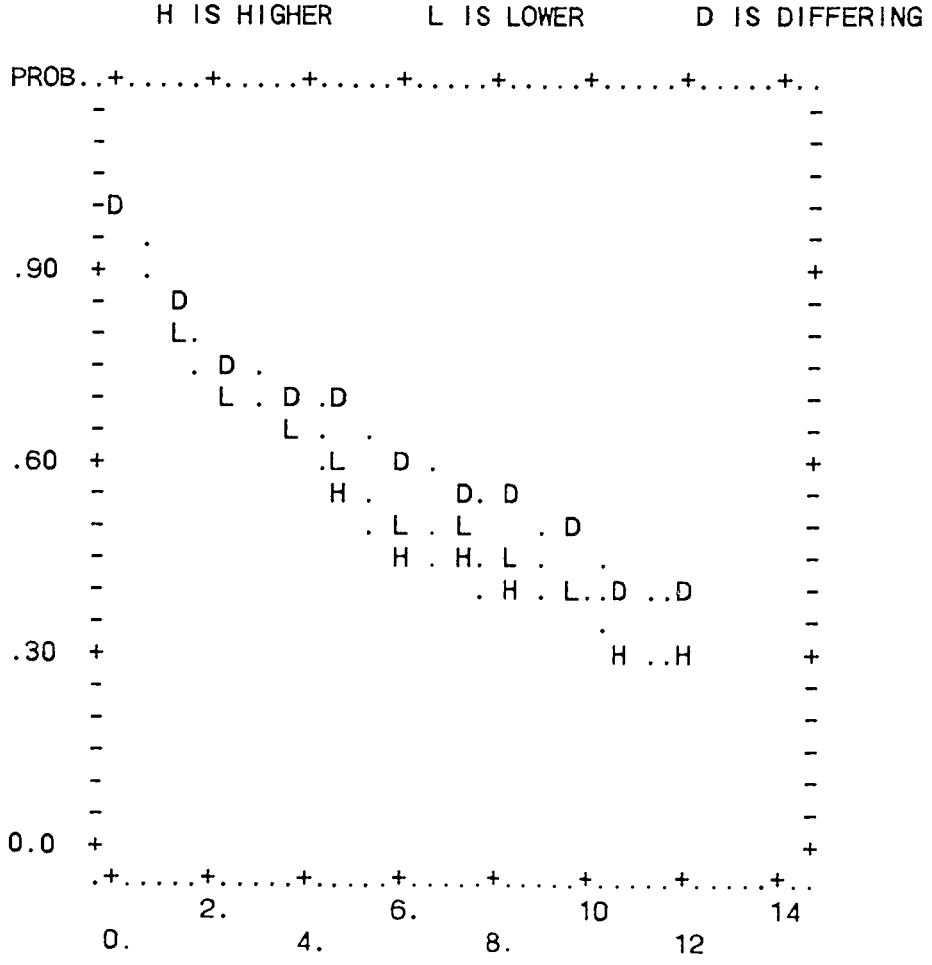

FIGURE 11. CUMULATIVE PROPORTION SURVIVING BY ECONOMIC CLASS

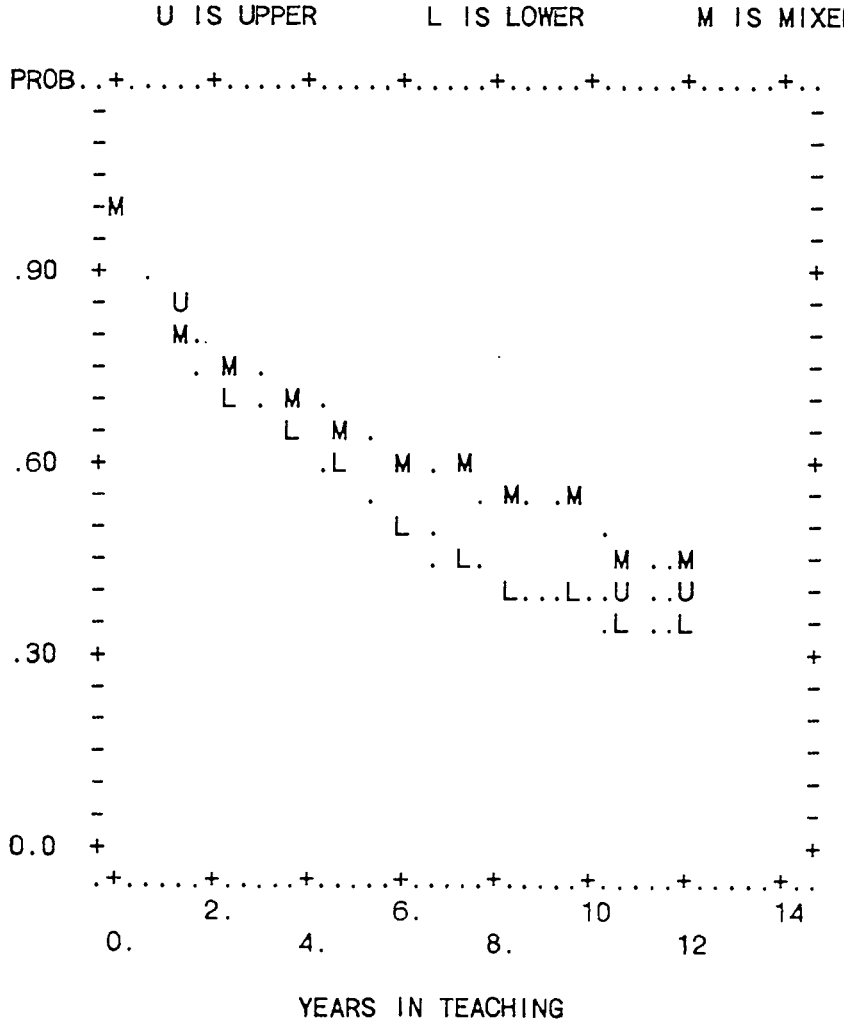

FIGURE 12. CUMULATIVE PROPORTION SURVIVING BY SIZE

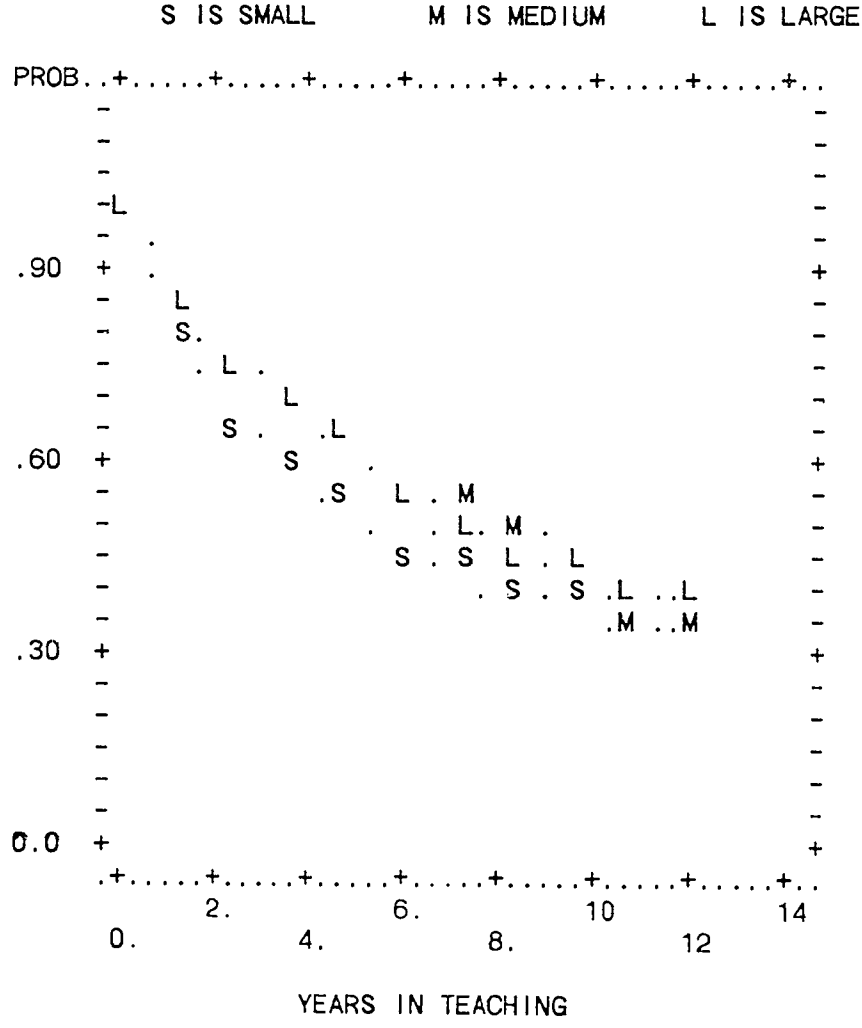

FIGURE 13. CUMULATIVE PROPORTION SURVIVING BY RACIAL COMPOSITION

M IS MINORITY I IS INTEGRATED W IS WHITE

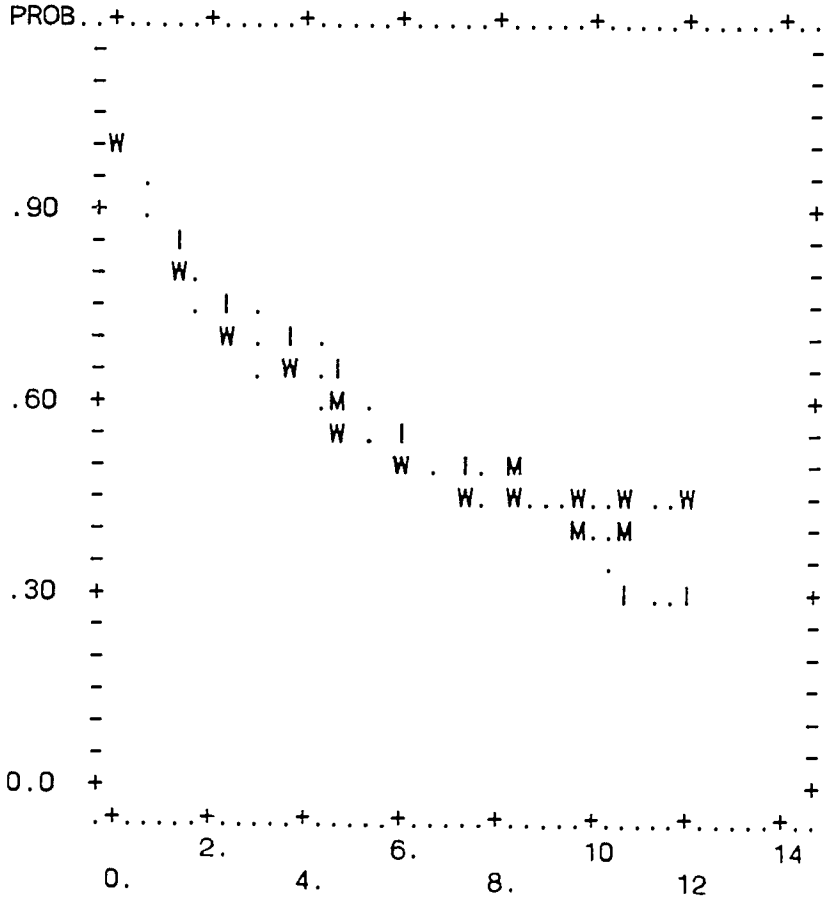

FIGURE 14. CUMULATIVE PROPORTION SURVIVING BY LOCATION

R IS RURAL S IS SUBURBAN U IS URBAN